

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Little White Creek, a Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*) Stream.

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ABSTRACT

Studies were conducted in 1996 on Little White Creek to determine instream flows necessary for maintaining Bonneville cutthroat trout (BRC) habitat and populations. Studies complemented ongoing habitat and population monitoring of BRC streams (Remmick et al. 1994). Physical Habitat Simulation (PHABSIM) and a habitat retention model were used to derive instream flow water right recommendations. Recommendations are: October 1 - May 14 = 1.2 cfs, May 15 - June 30 = 2.9 cfs, and July 1 to September 30 = 1.2 cfs.

INTRODUCTION

Wyoming Bonneville cutthroat trout (*Oncorhynchus clarki utah*) populations occur primarily in the Thomas Fork and Smiths Fork watersheds. These major Bear River tributaries and associated waterways were surveyed for physical, chemical, and biological characteristics between 1966 and 1977 (Miller 1977). Binns (1981) reviewed the distribution, genetic purity, and habitat conditions for Bonneville cutthroat trout populations. Recent population and habitat survey results are in Remmick (1981, 1987) and Remmick et al. (1994).

In general, populations are limited by seasonally low flows, lack of riparian cover, thermal pollution arising in conjunction with low flows and reduced riparian vegetation, and silt pollution (Binns 1981). Livestock grazing on both private and public lands is an important contributor to degraded habitat conditions. However, despite habitat challenges, significant populations remain throughout the native range and a recent review categorized Wyoming's populations as "95% secure, stable" (Duff 1996).

Population status in other Bonneville basin states including Utah, Idaho and Nevada is less secure. Therefore, Bonneville cutthroat trout were recently petitioned for listing under the Endangered Species Act but are not listed at this time. Status review was initiated in response to concerns expressed by the Idaho Fish and Game Department, the Desert Fishes Council and the Utah Wilderness Association. This species is considered "rare" in Wyoming by the Wyoming Game and Fish Department (WGFD 1977).

A 5-year management plan for Wyoming, developed by the Wyoming Game and Fish Department (WGFD) in coordination with the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), outlines management goals and provides criteria for listing Bonneville cutthroat trout as threatened (Remmick et al. 1994). The plan's purpose is to outline management practices to prevent listing by moving toward wider distribution and higher populations. The plan recommends that status decisions be made after five-years of population and habitat monitoring. Habitat protection by acquiring instream flow water rights will help prevent additional population declines.

Resource management practices could be significantly affected by listing Bonneville cutthroat trout as Threatened or Endangered. Instream flow water right identification and acquisition on Bonneville cutthroat trout streams is important to help avoid listing. Therefore, since 1993 the WGFD has filed for instream flow water rights on most non-ephemeral tributaries with documented BRC presence in the Thomas and Smiths Fork drainages. Studies in 1996 focused on Poker Hollow Creek, North Fork Smiths Fork Creek, Lander Creek, Trespass Creek, Packstring Creek, and Little White Creek.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Bonneville cutthroat trout and, 2) determine an instream flow regime necessary to maintain or improve Bonneville cutthroat trout populations.

## METHODS

### Study Area

Little White Creek is a small headwater tributary that flows generally southeast before entering Salt Creek downstream of Allred Flat campground (Figure 1). The stream's name is appropriate because the water color has a milky white cast from particles entrained while flowing over light-colored sedimentary deposits. The Wyoming portion of the Little White Creek basin is in the Bridger-Teton National Forest while the headwaters are in Idaho's Caribou National Forest. Grass and willow species occur in the riparian zone along with various sedge species. Stream gradient estimated from a USGS 7.5 minute quadrangle map averages about 4%. Channel type was rated as A4 (Rosgen 1985) indicating a headwater stream with relatively high gradient but occurring in a geological deposition area so that channel substrate is predominately small cobble, gravel and sand.

### Fisheries

The term "fishery" refers to fish populations and their associated habitat in a defined area. Instream flow water rights are intended to maintain or improve habitat conditions so that viable fisheries are maintained or improved. Trout populations, particularly in small mountain streams, normally fluctuate widely. In a western Oregon stream studied for 11 years, density of age 0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m<sup>2</sup> and density of age 1 cutthroat trout (juveniles, 4-4.5 inches) ranged from 16 to 34 per 100 m<sup>2</sup> (House 1995). In this example, population fluctuations occurred despite the fact that habitat conditions were not degraded and appeared to be relatively stable. The author suggested that small changes in peak winter flows between years would have accounted for shifts in overwinter survival between age-classes.

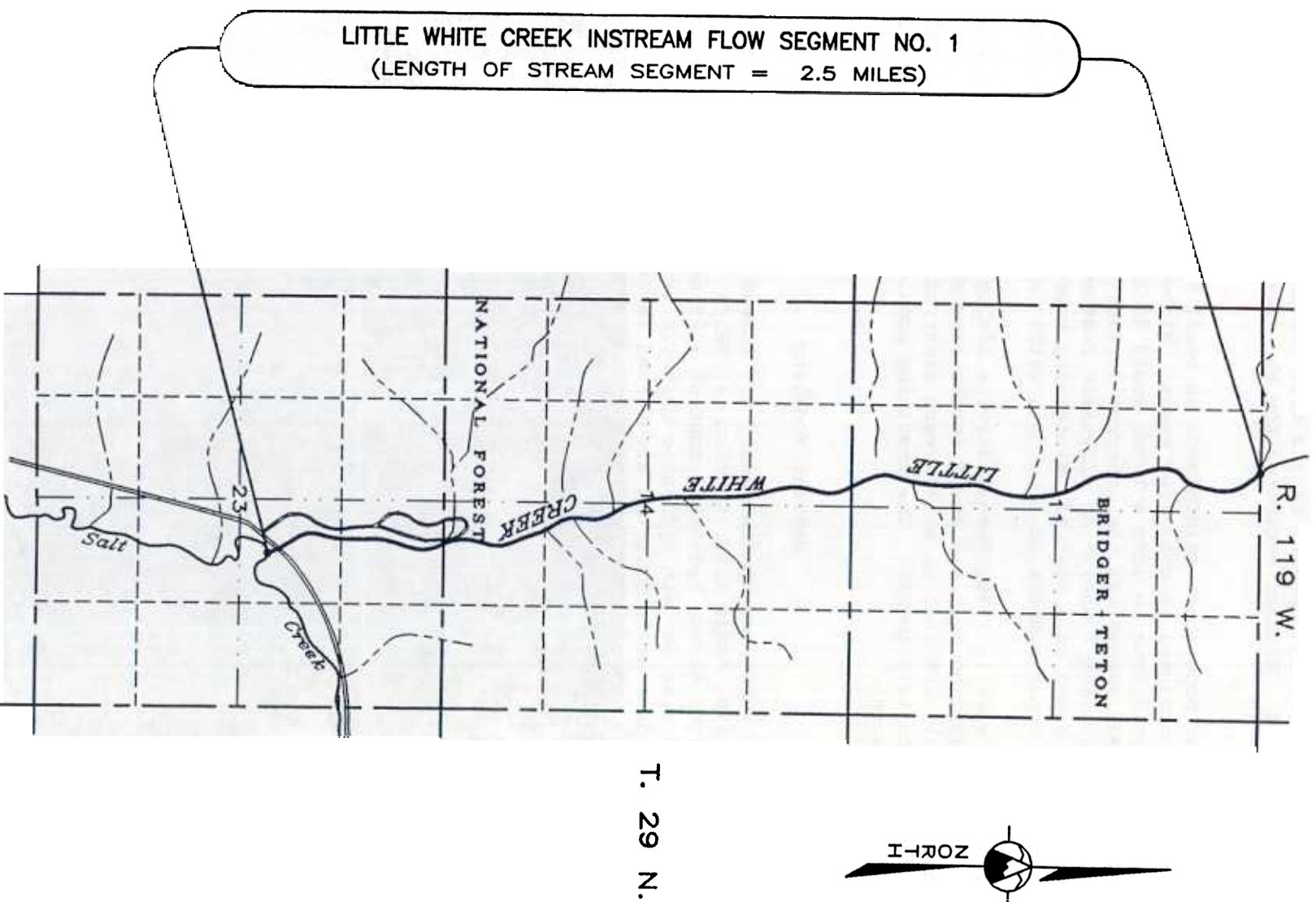


Figure 1. Little White Creek Instream Flow Segment No. 1

Similar population fluctuations occur in Sand Creek, a Crook County, Wyoming stream that experiences relatively little discharge variation (Mueller 1987). Sand Creek brown trout population density ranged from 646 trout/mile to 4,060 trout/mile in a three year period. Biomass estimates for the same period ranged between 48 and 142 pounds per acre.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations in some streams would decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

During survey work in 1995, Forest Service biologists collected 8 Bonneville cutthroat trout ranging between 4.5 and 8 inches from a 100 m section. On August 27, 1996 approximately 206 feet of stream were electrofished to yield 3 BRC ranging in length from 3.6 to 10.0 inches. The resulting population estimate was 103 trout per mile (32.5 lbs/acre).

#### Habitat Modeling

After visually surveying approximately 1.1 stream miles, a study area was located at Township 29N, Range 119W, Section 14, SE1/4. (Figure 1 and 2). Three perpendicular transects across hydraulic control riffles were used to determine a flow level that maintains certain hydraulic criteria (see below). Dates and flow levels during which data were collected are listed in Table 1.

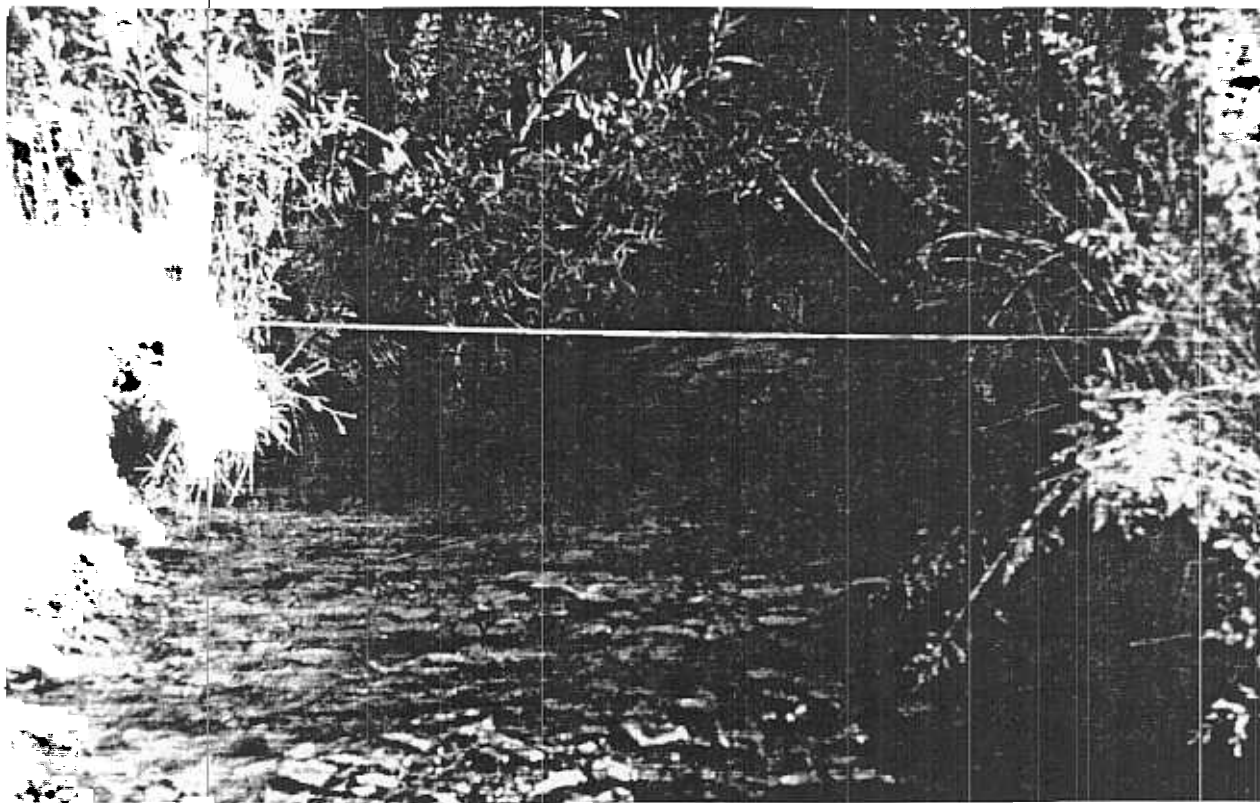


Figure 2. Habitat Retention transect 2.

Table 1. Dates and discharges instream flow data were collected in 1996

Date	Discharge (cfs)	Data
August 27	1.4	Population Estimate
September 9	1.0	Habitat Retention & PHABSIM

Instream flow filing recommendations derived from this site were applied to a 2.5 mile-long reach extending downstream from the boundary between sections 2 and 11 of T29N, R119W to the confluence with Salt Creek at T29N, R119W, S23. The land through which the proposed segment passes is under Bridger-Teton National Forest administration.

The small headwater nature of Little White Creek implies that deep water adult habitat is not abundant. Instead, small areas are suitable for moderate sized fish under normal flow conditions. It is likely that small tributaries in the Thomas and Smiths Fork drainages act as recruitment sources to the larger creeks. Spawning and nursery habitat in these tributaries appear plentiful during years with normal flow. Fry may passively drift down into the larger streams shortly after emergence or adults may emigrate as small pools no longer meet their energetic or predator avoidance needs. From a drainage-wide perspective, maintaining BRC populations should hinge on maintaining hydraulic connectivity between the small headwater tributaries and the larger streams. Therefore, our general approach with the small headwater tributaries was to simply determine a flow level that maintains habitat levels and retains flowing water through riffle areas. Such flow levels should ensure that normal processes of immigration and emigration can occur.

In addition, spawning flow recommendations were made in some headwater tributaries where identifiable habitat could be modeled and spawning was known to occur. Spawning trout were observed in Little White Creek on June 6, 1996 and recommendations were developed for this stream.

#### Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from the three hydraulic control riffle transects added on September 9. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance in riffles ensures that habitat is also maintained in other habitat types such as runs or pools (Nehring 1979). In addition, maintenance of identified flow levels may ensure passage between habitat types for all trout life stages and maintain adequate benthic invertebrate survival.

A maintenance flow is realized at the discharge for which any two of the three criteria in Table 2 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round.

Table 2. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

Category	Criteria
Mean Depth (ft)	Top Width <sup>a</sup> X 0.01
Mean Velocity (ft/s)	1.00
Wetted Perimeter (%) <sup>b</sup>	50

a - At average daily flow or mean depth = 0.20, whichever is greater

b - Percent of bank full wetted perimeter

Simulation tools and calibration techniques used for hydraulic simulation in PHABSIM (Physical Habitat Simulation) are also used with this technique. The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft<sup>2</sup> per 1000 ft of stream length) at various flows. In habitat retention, only hydraulic control riffles are examined and no direct reference is made to suitability of identified depths and velocities for trout life stages. Instead, the AVDEPTH model under PHABSIM is used to simulate average cross section depth, wetted perimeter and velocity for a range of flows on each cross section. The flow that maintains 2 out of 3 criteria for all three transects is then readily apparent.

#### Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability for spawning Bonneville cutthroat trout over a range of discharges. The methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft<sup>2</sup> per 1000 ft of stream length) at various flows. Depth, velocity, and substrate data collected along transects used in habitat retention calculations were also used for modeling spawning habitat quantity. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were used to incrementally estimate physical habitat between 0.1 and 3.0 cfs.

Curves describing depth, velocity and substrate suitability for spawning Bonneville cutthroat trout are an important component of the PHABSIM modeling process. Suitability curves used for deriving recommendations are listed in Appendix 1.

Binns (1981) estimated that peak Bonneville cutthroat trout spawning occurs during periods of maximum run-off and average water temperatures between 45° and 48° F. These conditions are most likely to occur during late May or early June in Little White Creek (stream elevation 6800-7400+ feet; mean basin elevation = 7720).

Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed before the end of this period, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering. The PHABSIM model was used in making flow recommendations for maintaining BRC spawning habitat from May 15 to June 30.

The time periods selected for spawning flow recommendations differ among streams. Because it is the highest elevation stream examined, Poker Hollow Creek's spawning flow recommendation is for June only. On Little White Creek, the lower elevation means that spawning may begin in late May hence the recommended May 15 to June 30 period. Spawning recommendations for many BRC streams cover the entire May through June period. The lowest elevation streams (Huff Ck., Howland Creek, Salt Creek) have spawning recommendations applied from April 15 through June 30.

## RESULTS AND DISCUSSION

### Habitat Retention Analysis

Habitat retention analysis indicates that 1.2 cfs is required to maintain hydraulic criteria at all riffles (Table 3). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year.

Table 3. Simulated hydraulic criteria for three Little White Creek riffles  
Average daily flow = 2.4 cfs. Bank full discharge = 15 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.68	2.39	10.0	15
	0.43	<b>0.99<sup>a</sup></b>	6.1	2.5
	0.39	0.90	5.9	2.0
	0.35	0.77	5.7	1.5
	0.32	0.70	5.6	1.2
	0.30	0.64	5.4	1.0
	0.28	0.57	5.2	0.8
	0.25	0.50	<b>5.0<sup>a</sup></b>	<b>0.6<sup>b</sup></b>
	0.21	0.41	4.7	0.4
	<b>0.19<sup>a</sup></b>	0.36	4.5	0.3
	0.17	0.28	4.2	0.2
	Riffle 2	0.58	3.57	8.0
		0.26	1.34	7.2
		0.24	1.21	7.0
		0.22	1.04	6.8
		0.20	<b>0.99<sup>a</sup></b>	6.7
		<b>0.20<sup>a</sup></b>	0.91	6.7
		0.19	0.84	6.6
		0.15	0.65	6.4
		0.12	0.54	6.2
		0.09	0.36	6.0
		<0.09	<0.36	<6.0 <sup>a</sup>
Riffle 3	0.43	3.75	10.2	15
	>0.28	>1.96	<b>&gt;4.8<sup>a</sup></b>	>2.5
	0.26	1.76	4.7	2.0
	0.22	1.56	4.6	1.5
	0.21	1.42	4.5	1.3
	<b>0.20<sup>a</sup></b>	1.37	4.5	<b>1.2<sup>b</sup></b>
	0.19	1.27	4.4	1.0
	0.17	1.13	4.2	0.8
	0.16	<b>1.02<sup>a</sup></b>	3.8	0.6
	0.14	0.83	3.7	0.4
	0.10	0.58	3.3	0.2

a - Hydraulic criteria met

b - Discharge at which 2 of 3 hydraulic criteria are met

Trout populations are naturally limited by extreme winter conditions (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996). Formation of frazil ice (suspended ice crystals formed from super-chilled water) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source as resultant anchor ice limits habitat, causes localized de-watering, and extracts excessive metabolic demands on fish forced to seek ice-free habitats (Brown et. al 1994). Pools downstream from high gradient frazil ice-forming areas can accumulate anchor ice when woody debris or surface ice provides anchor points for frazil crystals (Brown et. al 1994, Cunjak and Caissie 1994). Such accumulations may result in mortalities if emigration is blocked by low winter flows or ice dams.

In high gradient systems, groundwater influx areas, ice covered pools not close to frazil sources, heavy snow cover with stream bridging, and pools with little woody debris offer refugia from frazil ice (Brown et al. 1994). Lower gradient streams and narrow streams are more likely to have insulating surface ice cover or at higher elevations, heavy snow cover and bridging. Little White Creek's high elevation, relatively narrow width and moderate slope likely means that heavy snow fall will result in snow bridging. Frazil ice formation is likely a concern mainly in early winter before sufficient insulating snow is present or in late winter when snow melt becomes superchilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 1.2 cfs should be maintained to maximize access to and availability of frazil-ice-free refugia. Any artificial reduction of natural winter stream flows could increase trout mortality and effectively reduce the number of fish the stream could support.

The 1.2 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns, occasional shortfalls during the winter do not imply a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.2 cfs, to maintain existing trout survival rates.

#### PHABSIM Analyses

Weighted usable area for spawning Bonneville cutthroat trout is illustrated in Figure 3. Peak spawning physical habitat over the simulated range occurs at 2.9 cfs. On all three transects, spawning habitat decreased at the highest flow simulated, 3.0 cfs, but this decrease is not evident for two transects when expressed as a percent of maximum spawning WUA (Figure 3). Since the flow range simulated is somewhat abbreviated, we can not be sure that spawning habitat does not actually peak at a flow level greater than 3.0 cfs. Therefore, additional study may be appropriate in the future if more precise information is needed.

Normal spring flows are estimated to peak at levels as high as 34 cfs based on Lowham's equation. Such high flows might limit spawning activity near the study site and these conditions probably cause trout to migrate to more favorable reaches or smaller tributaries to spawn. Though trout can usually find spawning habitat whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 2.9 cfs. Therefore, an instream flow of 2.9 cfs is recommended for the period May 15 to June 30.

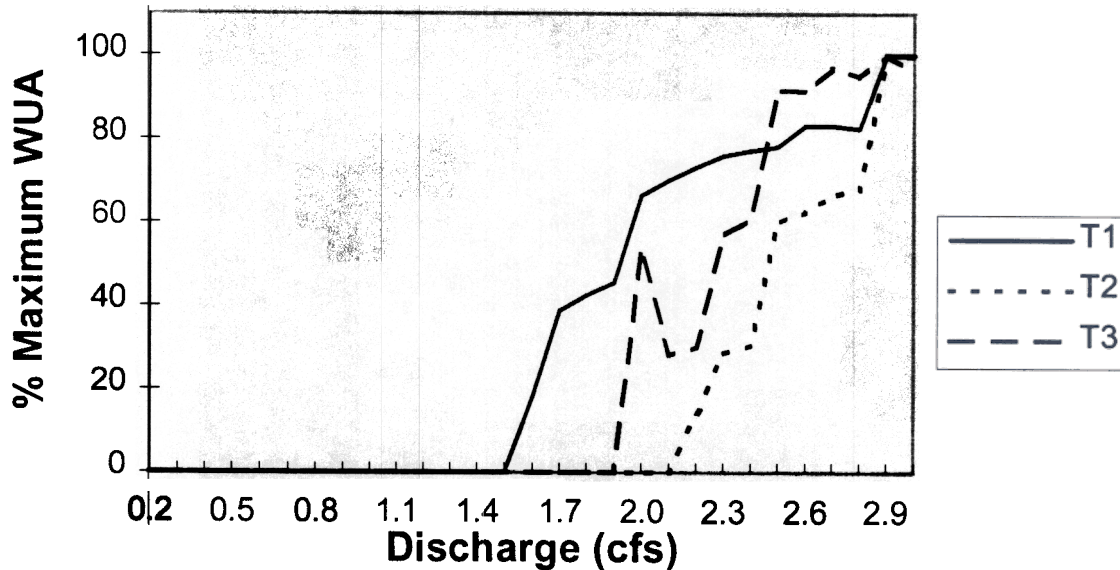


Figure 3. Weighted usable area (percent of maximum) for spawning Bonneville cutthroat trout in Little White Creek at three different transects over a range of discharges.

#### INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 4 will maintain the existing Little White Creek Bonneville cutthroat trout fishery. These recommendations apply to a 2.5 mile Little White Creek segment extending downstream from the boundary between sections 2 and 11 of T29N, R119W to the confluence with Salt Creek at T29N, R119W, S23. The land through which the proposed segment passes is under Bridger-Teton National Forest administration. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 4. Instream flow recommendations to maintain the existing Little White Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
October 1 to May 14	1.2
May 15 to June 30	2.9
July 1 to September 30	1.2

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations may be appropriate for establishing channel maintenance flow requirements.

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